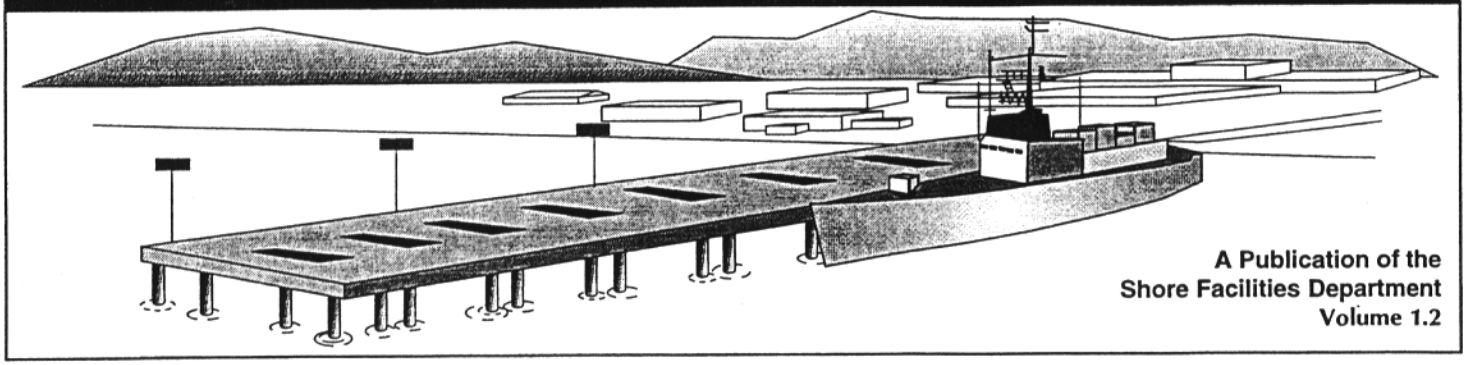
NFESC
Naval Facilities Engineering Command
1100 23rd Avenue
Port Hueneme, CA 93043-4328

On The Waterfront



A Publication of the
Shore Facilities Department
Volume 1.2

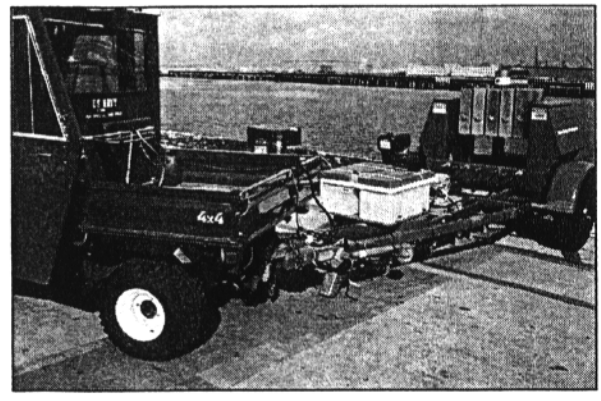
Falling Weight Raises Allowed Pier Loads

Crane load restrictions on four San Diego piers were eased after the ESC's non-destructive impact tests and advanced finite element models proved they could safely support lifts of ship components by mobile cranes. A trailer-mounted falling weight deflectometer collected load response data from hundreds of pier deck locations without interference to ongoing ship support missions. According to **LCDR Kim Weisenberger**, CINCPACFLT sponsor, the ESC Impact Load Test Method is a tool that can assist claimants in effectively spending pier repair funds.

Unlike code-based and simplified beam formula analyses typically used by A/E firms, the ESC impact method directly measures a structure's response to load. PWC engineers can, thus, precisely know a pier's load performance limits and can set the factor of safety to be used for crane operations. In the absence of cost prohibitive and time consuming static load tests, A/E procedures are overly conservative and result in unknown, but extremely high, factors of safety. The result is unwarranted restriction of crane operations. These restrictions ultimately lead claimants to program projects costing $30M to $50M to demolish and replace piers and wharves that are still capable of meeting mission requirements.

According to **LCDR David Kelly**, NAVSTA San Diego Staff Civil Engineer, a recent A/E study of Piers 10, 11, and 12 recommended restriction of crane outrigger loads to 6,000 pounds on the 8-inch decks, thereby effectively prohibiting crane operations. In contrast, the ESC impact-based assessment indicated that outrigger loading could be increased to 17,800 pounds over the 8-inch thick decks and outrigger loads as high as 100,000 pounds could be safely supported if the crane outriggers were located over pile caps. According to **LT Juan Robertson**, FISC San Diego Staff Civil Engineer, an A/E study recommended prohibiting crane lifts and restricting uniform live loads on Pier 11A to 250 psf. The ESC impact-based assessment confirmed the prohibition on crane operations; however, it demonstrated that the 54-year old pier could still safely support its design uniform live load of 600 psf.

Impact load assessment is a rapid, affordable and non-intrusive service. It can help you assess the safety of waterfront structures that are being pressed into missions for which they were not originally designed, or are deteriorating after years of service. The method is a tool you can use to assist in establishing safe operating practices and in prioritizing expenditure of funds for repair and upgrading.



Falling weight deflectometer impacts San Diego Pier.

If your pier or its utility system are inadequate to meet your customer's requirements, the ESC offers a full range of assessment and repair services. Our services include under and above water inspection, materials testing, repair strategies, and engineering drawings to fully rehabilitate your pier or wharf.

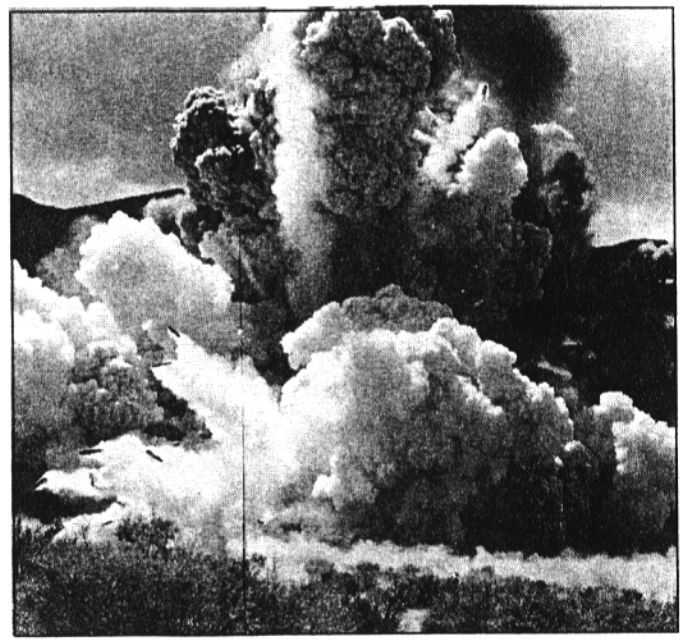
For further information or assistance, contact Dr. George Warren, ESC62, DSN 551-1236, (805) 982-1236, or Internet: gwarren@nfesc.navy.mil.

Inside

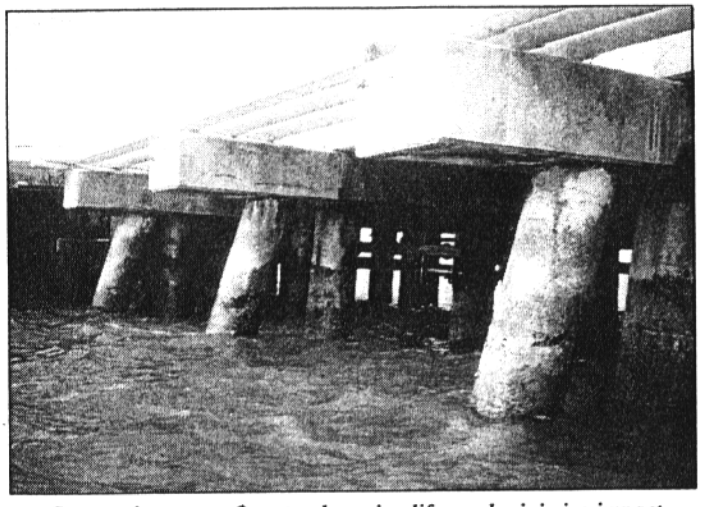
Shore Facilities Department

The **Shore Facilities Department** provides technology and specialized engineering services to plan, design, construct, maintain, and operate the Navy's shore infrastructure in support of Fleet readiness and operations. The Department produces timely and affordable engineering solutions for a diverse customer base, including PWCs, EFDs, Fleet and Shore Activities, SYSCOMs, and DOD. The NAVFAC Chief Engineer's Office, a department component, provides consulting and expert witness services for unusual and complex facilities engineering issues. Major Department areas of expertise include materials and composites, corrosion engineering, computer-aided-design and mapping, seismic engineering, and physical security. The Department offers specialized services for hyperbaric and dry-dock certification, load safety assessment, testing and analysis of materials and coatings, computer networking and installation management, security systems testing, and turnkey design and installation of electronics systems. Principal product areas include:

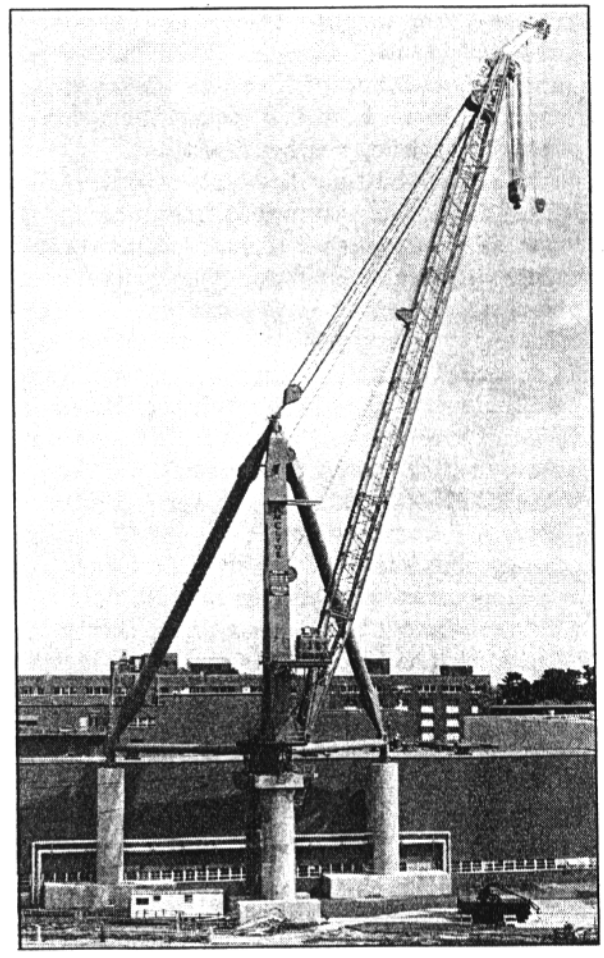
- Waterfront Facilities
- Physical Security
- Ordnance Facilities
- Aviation Facilities
- Installation Life Cycle Management
- Electronics Facilities



Maximize safety and affordability of ordnance facilities.



Save maintenance $, extend service life, and minimize impact on operations during waterfront repairs.



Enhance readiness and save $ by rapid safety assessment and certification.

PUTTING US TO WORK FOR YOU!!

NFESC is a DBOF organization with some interim Mission Management components. To put us to work for you, call the technical department, division, or individual engineer or scientist to begin developing a scope of work and a cost estimate. We accept funds on SF2275 and SF2276.

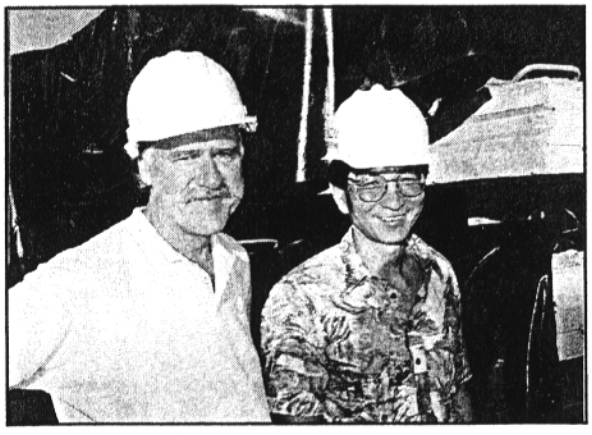
Prefabricated Epoxy-Coated Steel Reinforcement for Oceans and Other Severe Environments (PROSE)

In this issue we address improvements to one important construction material on the waterfront: reinforced concrete.

By using newly developed specifications for epoxy-coated rebar, you can build reinforced concrete structures that will last longer and require fewer repairs. These new specifications are being used for several new Navy MCON projects.

Mr. Mel Tsutahara, PACDIV Code 402, Structural Division has lead the Navy design team to incorporate the new technology into two MCON projects in Pearl Harbor: Submarine Wharf P117, a $13 million project constructed by Nova Group and Ford Island Bridge, a $78 million design/build project awarded to Dillingham/Manson.

Y-2 Contractor, Nova Group, placing prestressed concrete piles at Pearl Harbor.

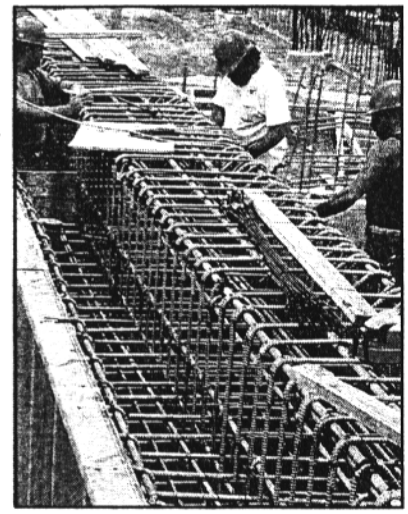


Douglas Burke, NFESC Senior Materials Engineer, with Mel Tsutahara, PACDIV Code 402, inspect concrete piles at SUBASE Pearl Harbor Y-2 Berthing Wharf.

On the east coast, the technology is being demonstrated in construction with the help of **Mr. Greg Retzler**, NORTHDIV Code 402, to construct Submarine Wharf P428 in New London, CT. The plan to demonstrate the technology was developed and managed by **Mr. David Curfman**, Special Assistant for Waterfront and Harbors, NAVFAC Criteria Office, Code 15C.

Problems and failures connected with using fusion bonded epoxy-coated steel reinforcement surfaced in bridges in the 1980s. After considerable investigations, it was concluded that epoxy-coated rebar, as then produced, could not deliver the long-term protection in wet, salty environments that had been previously believed. Specifically, the Canadian Strategic Highway Research Program (CSHRP) concluded in 1992 that epoxy-coated steel reinforcing bars will extend the life of a structure only an average of 5 years. Whereas the expectation of the customer was that the coated rebar should extend the life of the structure an additional 50 years.

To meet the customer's expectations, **Mr. Doug Burke** of the ESC Waterfront Materials Division, ESC63, conducted an ONR sponsored research and worked with industry experts to define an improved coating and manufacturing processes. A new technical approach was identified using less flexible "non-bendable" coatings and prefabrication methods.



Placement of epoxy-coated rebar in Hawaii per NFGS 03202.

Mr. Curfman tasked NFESC to work with field activities to demonstrate the new technology on full-scale construction projects and to work with the American Society of Testing and Materials (ASTM). To implement new standards for epoxy-coated rebar, Mr. Burke wrote two new Naval Facilities Guide Specifications: NFGS 030201 for manufacturing and NFGS 03202 for placement of prefabricated epoxy-coated steel reinforcement for oceans and other severe environments (**PROSE**). The new technology was reviewed by the Navy's Waterfront User's Group.

Mr. Burke worked with ASTM to develop a new industry standard. ASTM Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars A 934/A 934 M-95 was approved in May 1995. ASTM is working with the International Standards Organization to develop the first international standard for epoxy coated reinforcement.

NFESC provided technology transfer assistance to private sector design firms and construction companies to incorporate this new technology into non-Navy waterfront construction projects. The $200 million expansion to Muni-Metro/BART built by Bechtel Corporation and Pier 39, both in San Francisco, are examples.

For further information or assistance, contact Doug Burke at (805) 982-1055, DSN 551-1055, Fax (805) 982-1074, or Internet: dburke@nfesc.navy.mil.

Are You Ready for the Big One?

Earthquakes, like death and taxes, are inevitable. The 1989 Loma Prieta and 1993 Guam earthquakes alone caused over $275 million in damage to Navy facilities. Most of the Navy shore infrastructure is located in seismically active regions. Navy waterfront facilities are also usually founded on marginal soil with a high water table and are therefore especially vulnerable to earthquake generated soil liquefaction. **When the big one hits, how will your critical facilities fare?**

Soil settlement - 1994 Guam earthquake.

The NFESC provides a range of services to assist you in your earthquake preparations. Our engineers can predict the seismic threat to your facilities. We also can predict the performance of your structures, and develop plans to strengthen structures that are mission critical or whose failure would threaten life safety.

Our services include site seismicity studies, soil evaluation, and structural analysis. A site seismicity study will quantify the earthquake hazard level for your region and site. The soil evaluation will determine your sites vulnerability to liquefaction: a severe loss of soil strength associated with ground deformation and settlement. The structural analysis will determine the ability of your buildings to withstand the seismic threat. NFESC engineers have performed site seismicity studies for SouthWestDiv and performed seismic structural analysis for the Naval Air Station at Fallon, Nevada, and the Naval Surface Warfare Center at Crane, Indiana.

The remainder of this article describes our site seismicity study and soil evaluation services. Future articles will describe additional seismic services. Please let us know if we can be of assistance to you.

Site Seismicity Studies

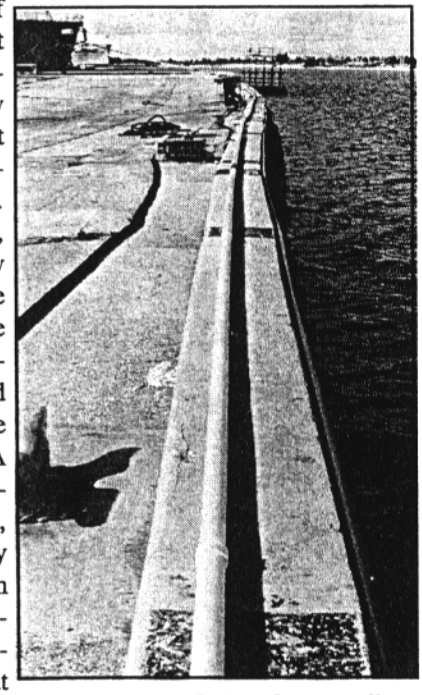
A seismicity study determines the intensity and characteristics of ground motion shaking that threaten your location. NFESC has developed a series of tools that use historical epicenter data and available geologic data to compute the probability distribution of site ground motion.

The product of our seismicity study is an engineering report that describes the site acceleration probability distribution and the site acceleration levels specified for analysis and design of your structures. We use a database of recorded earthquakes to generate a series of spectra of earthquake time histories for use by structural and geotechnical engineers. These spectra are included in our engineering report.

To quantify the level of hazard we build a mathematical seismic model that will estimate ground motion at your site for seismic events with a return time on the order of 1,000 years. Our engineering procedure minimizes effort and cost and provides a level of information that is appropriate to your requirement. We do not consider procedures that require panels of experts or extensive geologic investigation to be practical or feasible for limited scope engineering investigations. However, our investigation uses all available geologic, seismic, and tectonic data.

The controlling elements of seismic source characterization depends on the tectonic environment of your region. In the Western United States, earthquakes are associated with known faults; whereas, in the Eastern United States, the causative geologic structures are not generally well defined.

Large earthquakes in the Western United States are associated with faults. A 200-mile fault rupture is required to release the amount of energy associated with a seismic event registering 8.0 on the Richter scale. Since there is visual evidence of this 200-mile fault, it is unlikely to remain undiscovered. It is possible for lower magnitude events that require considerably less fault rupture to occur on faults that lack recent evidence of activity, or on faults that have not been identified. Where faults are identified as sources, we define the area contained within the model source zone as having relatively uniform seismic potential in terms of maximum magnitude and event recurrence. Where a fault exhibits variations of activity along its length, we divide it into subelements containing regions where activity is uniform.



Pore pressure damaged quay wall.

In the Eastern United States, faulting may not be readily identifiable. We then define source zones as regions where a zone of like seismicity is evident. The regional geology and tectonics help us define the source zone boundaries. A source zone is defined as a region of uniform seismicity, such that an event is equally likely to occur in any portion of the zone. This is characterized by the concept of a "floating earthquake," an event that can occur anywhere in the zone.

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Once a fault or region has been defined as a seismic source, we determine the maximum earthquake it might produce. The length of a fault can be estimated from maps and related to fault rupture potential. This estimate of rupture distance can be used to predict earthquake magnitude. Estimates of fault magnitudes and recurrence parameters have been made for some Western United States faults. When not defined by previous data, we can estimate the recurrence parameters that measure the level of seismic activity from a subset of earthquake events from the source zone. We also add two important elements to this information - geologic slip data and use of a characteristic magnitude model. Geologic data may show the presence of a characteristic magnitude event occurring at some regular return time. The seismicity defined by the relatively short term historical data fails to capture this activity, so it is important to include this information.

Soil Evaluation

Soil conditions at your site can significantly amplify the ground motion, which is transmitted from an earthquake centered many miles away. This is especially true for soft soil deposits and high plasticity clays that underlie waterfront sites. High plasticity clays were a major cause of the high acceleration observed in the San Francisco Marina District and on NAS Treasure Island during the Loma Prieta earthquake. We can use soil boring logs to estimate amplification at your site by using wave propagation analysis techniques. We can also use standard penetration blowcount data from the boring logs to evaluate the liquefaction potential of your site. Our recent studies developed analytical tools to estimate lateral ground spreading and vertical settlement from the occurrence of liquefaction. We can design soil retaining structures to withstand the increased horizontal forces that result from changes in load distribution as the backfill undergoes increases in pore water pressure.

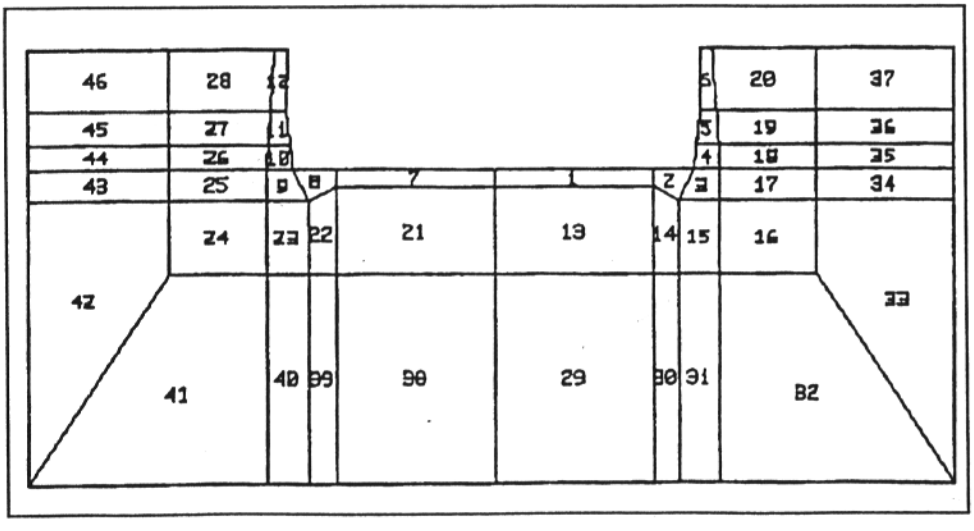
For additional information or assistance, contact John Ferritto, ESC62, at (805) 982-1243, DSN 551-1243, or Internet: jferrit@nfesc.navy.mil.

Restore Operations and Save Money with GENESEOS

Accurate and Quick Solution of Difficult Structural Problems

Finite element analysis can often help you find a better answer to difficult engineering problems, which involve complex structures, dynamically applied loads or soil-structure interaction. These problems are usually solved by making a series of simplifying assumptions to permit solution by classical formulas. The penalty in that approach is over conservatism. The result may be unnecessary restrictions on your fleet customer's operations or needless expenditure of money to replace structures that can still perform their intended function. Finite element analysis provides a better solution by closely modeling the true structure. It gives answers which enable the designer to have a better understanding of the factor of safety inherent in the structure and load condition.

ESC engineers are proficient with a range of finite element analysis tools -- **GENESEOS** is one of our newest. We developed GENESEOS to eliminate shortcomings in commercial codes that we found when analyzing the response of reinforced concrete structures and soil systems to dynamic loads. We have used GENESEOS to analyze geostatic stresses in dry-dock foundations, consolidation of dry-dock foundations, dynamic soil/structure interaction of dry-docks, foundation/dry-dock/blocked vessel interaction, steel hyperbaric chamber safety, acrylic view port safety, and performance of pier strengthening systems.



Geneseos drydock model.

GENESEOS is designed with a modular, object-based architecture. This allows the most appropriate 2D or 3D continuum elements, structural elements, or concrete or soil material models to be selected for analysis of your facility and loading. This architecture simplifies our continual updating of GENESEOS as new material models or algorithms are developed. Powerful preprocessing graphics simplify the geometric modeling of the most complex structure and vivid color post-processing graphics highlight stress distributions and deformations to simplify design or safety decisions.

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NAVAL FACILITIES ENGINEERING SERVICE CENTER

Mission

We are the Navy's center for specialized facilities engineering and technology. In partnership with our customers we deliver quality products and services in:

- Shore, Ocean, and Waterfront Facilities
- Environment
- Amphibious and Expeditionary Operations
- Energy and Utilities

As a member of the NAVFAC team, we provide worldwide support to:

- NAVFACHQ, EFDs/EFAs, and PWCs
- Fleet and Shore Activities
- Marine Corps
- SYSCOMs/Claimants
- SECNAV/CNO
- Other DOD Agencies

We provide solutions to problems through engineering, design, construction, consultation, test and evaluation, technology implementation, and management support. We leverage technology to enhance the effectiveness and efficiency of our customers. We use existing technology where we can. We identify and adapt breakthrough technology when appropriate. We perform research and development when required to meet Navy and Marine Corps needs.

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The GENESEOS material model library includes a third generation effective stress soil model that is particularly suited to modeling clays and silts in geotechnical structures and a unique elasto-plastic bond-slip model for reinforced concrete, which is excellent for modeling reinforcing steel anchorage problems. GENESEOS also contains standard linear elastic material models.

The loads and load conditions that can be modeled include:

- Concentrated and Distributed Loads
- Gravity and Body Force Loads
- Edge and Line Loads
- Piece-wise and User Defined Functions (for temporal and spatial variations of loads)

How Can You Use GENESEOS?

Our structural engineers can directly analyze your structure using GENESEOS or a number of other finite element analysis codes. We'll select the one that best fits your structure and loading.

Alternatively, we can customize GENESEOS to provide the structural or stress analysis program that best meets your requirements and provide it for your use. It can be delivered in an object code version for your platforms, whether they are Macintosh, Power PC, MS-DOS computers, or larger UNIX workstations. Our support package includes user documentation, example analyses, training, and customer support.

For additional information or assistance, contact Dr. Ted Shugar, (805) 982-1235, DSN 551-1235, or Internet: tshug@nfesc.navy.mil.

NFESC Organization

Shore Facilities Department

Responsible for developing technological tools and services to best support a viable Naval shore establishment.

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Ocean Facilities Department

Responsible for developing and improving the Navy's capabilities for the design, construction, maintenance, and repair of fixed ocean facilities.

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Norman D. Albertsen
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Amphibious & Expeditionary Department

Responsible for developing and providing support and enhancement of Naval Construction Battalion and Marine Corps advanced base construction and operations, amphibious force operations, and Marine Corps combat engineer operations.

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Environmental Department

Responsible for assembling customized technology to meet the environmental requirements of the Naval shore establishment.

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Energy & Utilities Department

Provides expert, specialized energy and utilities engineering services in support of the NFESC's mission.

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Newsflash!!

As we go to press, work is being completed on NFESC's home page on the World Wide Web. Look for us at http://www.nfesc.navy.mil.

On the Waterfront is an unofficial publication of the Shore Facilities Department, Naval Facilities Engineering Service Center, Port Hueneme, CA 93043-4328. Editorial views and opinions are those of the authors and not necessarily those of the United States Navy.

If you have any comments or questions, suggestions for future articles, or would like to receive copies of "On the Waterfront," call or write to **Mr. Joe Connett, Code ESC60APM, (805) 982-1570; DSN: 551-1570; FAX: (805) 982-3481, or Internet: jconnet@nfesc.navy.mil.**

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